

# Methodology of Designing the Pithy Components of Elective Courses on the Higher Mathematics of Pedagogical Profile

Ulan Bekish<sup>1</sup>, Duisebek Nurgaby<sup>1</sup>, Amandos Tulegulov<sup>2</sup>, Gulsim Abdoldinova<sup>2</sup>, Zhuldyz Basheyeva<sup>3</sup>

<sup>1</sup> Zhetysu State University named after I. Zhansugurov, Taldykorgan, Kazakhstan.

<sup>2</sup> The University of Technology and Business, Nur-Sultan, Kazakhstan.

<sup>3</sup> L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan.

ORCID: 0000-0001-9605-2101 (Zhuldyz Basheyeva)

## Abstract

The significance of the problem under study is due to the fact that the methodology of teaching students - future mathematics teachers of scientific knowledge is based on the idea of projecting the activities of a mathematics teacher with scientific knowledge on the process of studying the educational material of a school mathematics course. It includes the target (learning outcomes), substantive (pithy component systems), as well as processural (teaching methods and means) components. In this case, the main means of teaching students - future mathematics teachers is a system of tasks, the execution of which contributes to the formation of scientific knowledge, models the work of a mathematics teacher in the study of mathematical allegations.

This article identifies the problems of designing and developing the content of elective courses in the system of higher pedagogical education, the psychological and pedagogical factors of students' assimilation of the content of educational (scientific) material in the study of elective disciplines determined, the theoretical foundations of designing the content of educational materials are determined, pithy meaningful components of elective courses based on the principles and criteria of pedagogical didactics have been developed, complementing the existing system of pithy components of mathematical disciplines, a methodology for the development and use of substantial components is proposed, the possibility of realizing their basic functions to form professional knowledge and skills of students - future mathematics teachers is justified, the basic requirements for designing the content of the educational material of elective disciplines are determined.

**Keywords:** Elective Disciplines, Scientific Content, Educational Material, Pithy Components, Student Learning, Teaching Methods.

## I. INTRODUCTION

With the introduction of updated generally binding standards of higher and postgraduate education in the Republic of Kazakhstan (State compulsory standard of higher education of the Republic of Kazakhstan, 2018), the goal of higher education is to comprehensively develop the student's abilities and skills to self-education. Practice shows that there is some progress in

the teaching of mathematical disciplines; however, there is still a big difference between the competence of a university graduate and the requirements of the employer (Stevens, S; Mills, R & Kuchel, L. (2019) et al).

On the other hand, the knowledge contained in scientific and pedagogical literature, especially the use of this knowledge in practical work, inevitably confronts a future teacher with new concepts and methods, psychological and pedagogical problems which are not adequately reflected in university programs. The professional training of a future mathematics teacher is inextricably linked with three key interacting components of the learning process: the content of educational material, the teaching of mathematics and the cognitive activity of students.

Teaching mathematics is a joint activity of a teacher and a student, which is mainly determined by the content of the educational material, because the content of the educational material of the elective discipline as the main component of the educational program is a predefined invariant to which students need to be taught. Therefore, the content of educational material is one of the most important structural elements of the learning process.

All these issues should be taken into account when designing educational material and substantial components of elective disciplines. Consequently, the issues of developing and filling content of elective disciplines and their pithy components become relevant. The relevance of this study is due to the unelaborated methodology of designing and filling the scientific content of elective disciplines and their pithy components.

Our goal is to develop a methodology for designing and filling of pithy components that would allow students to form a high level knowledge, skills for conducting independent scientific research, as well as effectively eliminating gaps in the assimilation of educational material for this particular student.

## II. LITERATURE REVIEW

The problems of education and the content of educational programs are reflected in many domestic and foreign studies (Yu.K. Babansky(1988), M.V. Pototsky(1975), V.V. Kraevsky, I.Ya Lerner (1983), V.S. Lednev (1991), Francis Riesa, Cristina Yanes Cabrerab & Ricardo González Carriedoc,

(2016), A.E. Abylkasymova, et al (2001), A.K. Kagazbaeva (1999), Michelle Stephan, Cyril Julie, Fou-Lai Lin, Minoru Ohtani (2017), etc.)

The main components of the educational program are educational disciplines. The problems of choosing academic disciplines were investigated by Tian, Lin; Wu, Yan (2019), S.V. Nuzhnova (2014), A.A. Angelevsky (2010), G.G. Hamov (1994), et al.

Analysis of scientific and practical literature (Babansky, Yu.K. and Potashnik, M.M., (1983), Madden, A., Webber, S., Ford, N. and Crowder, M., (2018), Heather C. Hill, Merrie L. Blunk, et al (2008), Gubaidullina, G.N., (2012), et al) showed that the choice of the content of the academic discipline should be based on the following factors: the level of the student's mental ability; level of preparedness of students for the perception of educational material; level preparedness and experience of the teacher, from the correspondence of the content of educational material to level of modern science.

Scientific and pedagogical literature outlines some scientific-theoretical and practical prerequisites for teaching students - future teachers of mathematics to work with the content of educational material (A.A. Stolyar (1986), Wang, XL; Lee, SY(2019), A.G. Mordkovich (1986) Gibson, Suanne; Grace, Andrew; O'Sullivan, Ciaran, et al (2019), Roza A. Valeeva & Kadriya B. Shakirova (2015), V.A. Dalinger (2014), A.E. Abylkasymova (2016), L.T. Iskakova (2005), et al.).

Obviously, the content of the disciplines occupies an important place in the training of future teachers of mathematics. Therefore, it is necessary to determine those pedagogical principles and criteria (Yu.K. Babansky (1988), Gibson, Suanne; Grace, Andrew; O'Sullivan, Ciaran (2019), and others) that teachers should pay attention to the designing of the content of disciplines.

The issues of developing a modern textbook for secondary schools of the Republic of Kazakhstan are described in "Requirements for the development of a modern textbook for secondary schools of the Republic of Kazakhstan" (2017). However, they did not adequately reflect the issues of designing the pithy components of elective disciplines, including the problems of constructing the content of educational materials of mathematical disciplines in the field of higher pedagogical education and the formation of professional knowledge and skills through the pithy components of elective disciplines.

In this regard, questions arise of developing and filling the pithy components of elective disciplines, taking into account the holistic presentation of the issues of assimilation by students of the content of educational material and the methods of its training. At the same time, the problems of updating and constructing the content of educational materials that meet modern requirements of society turn out to be complex processes depending on the competence of the teacher and many psychological and pedagogical factors.

### III. METHODS AND DATA

At the present stage, the modernization of the world educational system is being carried out. The main prerequisites for the modernization and development of the global educational space are:

- increasing interest in the development of human capital
- Internationalization of education;
- increased competition in the economy
- Digitalization of economic processes, the transition to a smart society;
- Humanization of society;
- The growth of global, interstate and regional problems.

In this regard, in modern Kazakhstan, the process of updating the content of education is being carried out and new approaches to learning are being developed with it, oriented towards progressive educational, information, and communication technologies. This process presents new demands to graduate teachers. They should be creative, professionally responsible and competent, intellectually developed, highly motivated in cognitive activity.

"The program for updating the content of education in the Republic of Kazakhstan for 2011-2020" suggests that training should be active, conducted in the conditions of an created atmosphere of business cooperation, implement criteria-based assessment of student achievement, establish interdisciplinary communications, improve the professional competencies of teachers, and individualize instruction.

According to the "State compulsory standard of higher education of the Republic of Kazakhstan" (2018), the undergraduate educational program contains theoretical training including the study of cycles of general education, basic and majors disciplines. Moreover, the cycles of basic disciplines (BD) and major (special) disciplines (MD) include disciplines of the university component (UnK) and (or) component of choice (CC). UnK and CC (in further the elective courses) are determined independently by the university and take into account the needs of the labor market, the expectations of employers and the individual interests of the student. The database cycle includes the study of academic disciplines and the passage of professional practice and is at least 112 academic credits. The cycle MD includes educational disciplines and types of professional practices, the volume of which is at least 60 academic credits.

In accordance with this, we conclude that elective courses play an important role in shaping the expected learning outcomes. At the same time, elective disciplines are developed by university teachers taking into account their accumulated knowledge. However, they often do not pay attention to the fact that elective courses are courses that are designed to synchronously combine teaching methods, cognitive, research activities of a student.

In this regard, there is a need to formulate general requirements for elective courses, through which the design of the pithy components of elective courses is carried out.

The main approach to studying this problem is to design the content components of elective disciplines on the basis of psychological and pedagogical factors process of cognition of educational material, the basic principles and criteria of pedagogical didactics, the basic requirements put forward by Dublin descriptors.

Our proposed methodology for designing, filling and using the content components of elective disciplines studied in higher educational institutions of a pedagogical profile make a certain contribution to the theory of developing the content of academic disciplines allows you to complement the methods and means of forming professional knowledge and skills of students.

To solve this problem, we selected the following research methods:

- Theoretical: analysis of scientific literature on the topic of research; analysis of provisions, regulatory documents related to the learning process and the problem of research; the study of pedagogical experience of teachers of mathematical disciplines;
- Empirical: conversations with university teachers, students, undergraduates and school teachers; questioning of university teachers, students, undergraduates and young teachers; students' written works and their analysis; pedagogical experiment;
- Processing and analysis of experimental data using statistical research methods.

An experimental study was conducted from 2016 to 2019 under the usual conditions of the educational process of Zhetysu State University named after I. Zhansugurova and the Women's State Pedagogical University in the context of assimilation the mathematical content of elective disciplines.

#### IV. RESULTS

Let's notice that the content of elective courses mainly depends on the type of specialization. However, according to Dublin descriptors, and taking into account the program for updating of the content of education in the Republic of Kazakhstan, some general requirements can be defined for all elective courses. According to these conditions, we systematize the general requirements for elective courses studied by future teachers of mathematics.

Descriptors of the 1st level suggest following abilities (State compulsory standard of higher education of the Republic of Kazakhstan, 2018):

- 1) Demonstrate knowledge and understanding in the field of study area, including elements of the most advanced knowledge in this field;
- 2) Apply this knowledge and understanding on the professional level;
- 3) To formulate arguments and solve problems in the field of study;

4) To collect and interpret information to form judgments taking into account social, ethical and scientific considerations;

5) Communicate information, ideas, problems and solutions to both specialists and non-specialists

Therefore, so that students acquire and demonstrate advanced modern knowledge in the field of study, could apply and understand this knowledge at a professional level of the content of the elective course should:

- to eliminate the gaps in accumulated knowledge;
- to develop and expand the acquired knowledge of students so that basic disciplines supplemented by this elective course should become fully expanded by modern educational materials;
- implement interdisciplinary communications that contribute to the systematization of acquired knowledge;
- integrate the accumulated knowledge acquired in the framework of various subjects to solve research problems.

In the era of scientific and technological progress and post-industrial development of the economy there is an urgent need for the formation of professional knowledge and skills of students that contribute to their personal development, the realization of their capabilities in future professional activities.

Therefore, for the implementation of this task and in addition students could argue their ideas, set goals, formulate problems, solve the tasks and propose ways to solve the formulated problem in the studied area, the content of the elective course should:

- provide an opportunity for self-expression at a professional level, as well as for the personal development of students;
- create all the necessary conditions for the formation of an individual learning path.

In addition, for the formation of key competencies of graduates, it is necessary (State compulsory standard of higher education of the Republic of Kazakhstan, 2018) so that the student had an idea of current trends in the development of scientific knowledge, and he/she was able to use the knowledge gained to develop and apply his ideas in the context of scientific research; had the skills of research activities, solving standard scientific and pedagogical problems.

And therefore, the content of scientific and pedagogical disciplines should: contribute to the activation of educational activities of students; to introduce them to research work; to promote the effective use of the acquired knowledge to solve applied and scientific problems; to possess significant developing potential of students' mental activity.

The analysis of scientific and pedagogical literature allows us to conclude that the content of the elective course is relevant, if it provides the opportunity to implement a didactically sound combination of teaching mathematical knowledge and cognitive activity by acquisition this knowledge.

Given the above requirements now, we can offer the following general requirements for the content of the elective course:

- to develop and expand the acquired knowledge of students (to be an “advanced superstructure” of basic disciplines, that is, basic disciplines supplemented by given elective course should become fully expanded by modern teaching materials; implement interdisciplinary connections that facilitate the systematization of acquired knowledge);

-to provide an opportunity for personal self-expression at a professional level, as well as for the personal development of students (create all the necessary conditions for the formation of an individual learning trajectory);

-eliminate knowledge gaps;

-form the key competencies of graduates, develop professional knowledge, skills and abilities;

-contribute to the activation of cognitive and research activities of students (introduce them to research work; use the knowledge gained to solve applied and scientific problems);

-possess a significant developing potential of students' mental activity;

-Be relevant in the training of highly qualified personnel.

Over the past three years at Zhetysu State University named after I. Zhansugurov taught the elective course “Singularly perturbed general boundary value problems with boundary jumps for ordinary differential equations” (Nurgabyl D.N., Bekish U.A., 2017), which satisfy the above requirements.

The main goal of which is the integration of accumulated knowledge acquired in different disciplines, the activation of cognitive and research activities of students, the preparation of students for methods of implementing intersubjective communications in the process of teaching students mathematics in school.

The basic knowledge acquired by students in the study of this elective course is as follows:

- to know the history of singularly perturbed problems;

- to know the rule of determinants differentiation, the theorem on the multiplication of determinants, Bine's theorem, the decomposability of the determinant into sums of determinants, the properties of a linear transformation that are not studied, or studied superficially in the course of higher algebra;

- to know the definition and property of the initial and boundary functions that expand the concepts of functions;

- to know the phenomenon of a boundary jump, the study of which is an important circumstance taken into account when predicting chemical reactions;

- to know the theorems of the existence and uniqueness of initial and boundary functions;

- to know the algorithm for constructing solutions of singularly perturbed and unperturbed boundary value problems;

- to know the asymptotic behavior of the solution of a singularly perturbed boundary value problem with boundary jumps;

- to know the rule for finding asymptotic estimates, the theorem of A.N. Tikhonov about the limit transition.

Thus, while studying this course, previously acquired knowledge is consolidated, interdisciplinary relationships are established, the integration of accumulated knowledge is carried out, gets additional knowledge by other disciplines with the help of independent work, the cognitive and research activities of students are activated.

Starting to construct the content of the elective course, it is necessary to formulate the corresponding concept for each course, i.e., specifically answer to myself the following questions:

1. What is the purpose, what is the practical and theoretical significance of the proposed elective course?

2. What does this elective course give to the student as a future teacher of mathematics? As a result of studying this elective discipline, what knowledge and skills do students acquire?

3. What questions are the key questions in it? Which sections are the main ones?

4. What algorithm can be used to study the content of educational material?

5. Are there problems and methods, what is the development trend of the studied scientific knowledge? Are there any links between the basic concepts and ideas of elective discipline?

Detailed answers to these questions should be lighted in the preface of each elective course. It follows that the “Preface” (or “Introduction”) is a substantial component of each elective course, with the goal of which is to increase the motivation of students, the formation of a systemic presentation of scientific materials of the studied discipline.

When designing the scientific content of elective disciplines, the question arises of choosing the content of scientific materials, the development of the concept.

Solution to this problem consists in the study what is the most important in modern science, what should be offered to students for study - future teachers of mathematics. How to construct an academic discipline from a scientific theory?

What initial position to lay the basis for the content of the academic discipline, what concept to offer? From what scientific and methodological point of view should the main parts of the elective course be presented? and et al.

Contents of the scientific materials of the discipline may by different; however, the totality of the scientific knowledge offered to students for study should be logically holistic. Therefore, the key component of all academic disciplines is scientific knowledge. Depending on the purpose of studying elective disciplines, the following types of pithy component “The System of Scientifics Knowledge” can be distinguished:

- Component "System of scientific knowledge, the elements of which are contained in the school course of mathematics";

- Component "The system of scientific knowledge that provides the study of the foundations of modern mathematics."

When developing the content components of elective disciplines, it is necessary to ensure the study of this discipline taking into account the student's mental abilities. To this end,

in the content of elective disciplines should include a system of tasks and exercises that develop students' mental abilities. Such pithy components are the "The System of level tasks and exercises", "The system of logical tasks and exercises", and "The system of tasks for independent work of students".

A special place in the integration of scientific knowledge is occupied by mathematics. The integration capabilities of mathematics in the technical and natural sciences made it possible to create a coding theory, information systems, a theory of forecasting and economic planning, mathematical models of many real processes, and much more.

In this regard, the in content of elective disciplines should include tasks aimed at integrating scientific knowledge obtained in the framework of one or more disciplines.

Thus, "Tasks aimed at integrating scientific knowledge gained in the framework of one or more disciplines" are necessary a pithy component of elective disciplines is a necessary substantial component.

In the learning process, questions and assignments for preparing students for subsequent classes occupy a significant place, which ensures the effective assimilation of new educational material, as well as consolidates and systematizes the acquired knowledge of students.

Therefore, "Tasks and questions for consolidating and systematizing the acquired knowledge" is a substantial component of the elective disciplines studied by future mathematics teachers.

In the updated program of the school course in mathematics, special attention is paid to applied problems. In this regard, the content of elective courses should include applied tasks, as well as practical tasks of the surrounding world, which provide motivation for cognition of the phenomena of the surrounding world.

Therefore, "Applied Tasks", "Practical Tasks of the World" are the mandatory pithy components of elective disciplines.

In the organization of training, a special place is occupied by questions and tasks for the implementation of self-monitoring of student learning achievements. The following types of tasks and questions can be used for self-monitoring of acquired knowledge: text processing of educational material; preparation of abstracts of the answer to the questions posed for self-examination; solving model problems and exercises set for self-control.

Consequently, the "System of Assignments for Self-Testing Student Achievements" is one of the components in the content of elective disciplines.

After the knowledge of students is basically formed and systematized, it is necessary to assess the acquired knowledge of students. To increase the objectivity of assessing students' academic achievements, midterm and final control measures should be carried out based on the results of the study of individual topics and sections of elective disciplines.

The purpose of such control is to determine the level of mastering of the main content of the educational material. The

content of the tasks should include the key issues of the section, subsection, specific topic. Thus, we conclude that the "System of Assignments for the current, milestone and final control measures (tests, exams, colloquiums, etc.)" is a substantial component of elective disciplines.

The content of elective disciplines should include the sub-item "General statement of the studied problem", which includes questions and a brief annotation, which will allow students to better navigate the content of the elective course, will highlight the main content of the topic. In this regard, we conclude that the sub-item "General statement of the studied problem" is also a substantial component of elective disciplines.

The research work of students is organized at the university with the aim of providing a more informed and deeper assimilation of the content of the educational material and the acquisition by students of the initial skills of research work.

In this regard, the department, taking into account the requirements of employers, taking into account the views of students themselves, develops topics for the implementation of research projects and projects. Therefore, "Assignments to research and development projects and projects" is one of the systemically-forming a pithy component of the elective discipline.

An analysis of the designed a pithy component of the elective discipline allows them to be classified according to the basic requirements arising from the Dublin descriptors, goals and principles of instruction. These are the following pithy key components:

- Managing component (Introduction; Conclusion; Literature).
- The scientific - knowledge pithy component. This is a system of scientific knowledge: a system of scientific knowledge, the elements of which are contained in the school course of mathematics; a system of scientific knowledge that provides the study of the foundations of modern mathematics.
- The cognitive-activity component forms the knowledge, skills necessary for the implementation of the professional activities of future teachers of mathematics. With the help of this component, elective courses can be studied at an introductory, reproductive and professional level.
- The assessment component. This component is expressed in the presence of tasks that allow students to evaluate the educational achievements (Nurgaby D., Kalzhanova G. et al, 2017). This is a system of diagnostic and correctional tasks, a system of questions and tasks for self-testing and self-monitoring, a system of tasks for current, intermediate and final control measures;
- The systemically -forming a pithy component. This component is aimed at the formation of a systematic representation of the acquired scientific knowledge, at the development of the student's research, cognitive ability. These are: a system of applied tasks; system of problem tasks; tasks oriented to the formation of algorithmic ability; tasks for the formation of skills conducting independent scientific research: thesis and term papers or projects; comparative analysis of literature, etc.

Note that in the process of filling the pithy components, psychological and pedagogical requirements must be taken into account, i.e. the content of the components must satisfy the so-called ergonomic requirements. These are acquired knowledge, mental, psychological abilities, as well as motivational attitudes of students, manifested in the study of elective disciplines.

## V. DISCUSSION

The formulated pithy components are the main means of teaching the scientific content of educational materials, allow students to form a high level of knowledge, skills for conducting independent scientific research, as well as effectively eliminate gaps in the assimilation of educational material for this particular student.

The obtained results provide an opportunity for further research on the theory of constructing scientific content and substantive components of elective disciplines and will be useful in preparing textbooks for the formation of professional knowledge and skills of researchers, teachers, students and others.

Let's notice that considerable laboriousness and complexity of compiling the content components of elective disciplines is to take into account the level of students' education, the limited time allocated to the study of the discipline.

## VI. CONCLUSION

The final stage of the study was a formative experiment (2018-2019), the main purpose of which was to identify the effectiveness of the developed system of substantial components of elective disciplines in the process of teaching a student the scientific content of elective discipline.

At this stage, written work was carried out to determine the level of formed of the ability to solve professionally oriented tasks of students in the control and experimental groups, the following research methods were used: analysis of answers to questionnaire questions, methods of mathematical statistics, and the method of conversation.

During the experimental study, the study of the discipline "Singularly perturbed general boundary value problems with boundary jumps for ordinary differential equations" in the control group took place without making any changes to the content of the educational material, as well as to the process and teaching methods. An experimental study for two years was conducted at Zhetysu State University named after I. Zhansugurov and at Women's State Pedagogical University and in secondary schools (Republic of Kazakhstan). The sample size consisted of 46 students, 112 teachers of mathematics. Such a sample, despite its small size, has a rather high representativeness and can show statistically accurate results.

The experiment was to observe the amount correctly solved problems by students of the experimental and control groups during the written work. It was proved that both samples are independent and obtained from the general totalities  $X$  and

$Y$ , having normal distributions. To verify the assumption of a normal distribution of populations, the criterion of agreement was used.

The hypotheses were formulated:

$H_0$ : The differences in the distribution of students in the experimental and control groups by the level of formed of the ability to solve professionally oriented tasks are statistically insignificant.

$H_1$ : The differences in the distribution of students in the experimental and control groups according to the level of formed of the ability to solve professionally oriented tasks are statically significant.

The calculation of the empirical values of Student's t-test showed that:

$$\sigma_{x-y} = 0,4369 ; t_{эмн} = 2,5177 , t_{кpum} = 2,015$$

and  $t_{эмн} > t_{кpum}$ .

In connection with this result, at significance level, hypothesis was rejected and hypothesis was adopted. Thus, we were convinced that at the final formed stage, the differences in the distribution of students in the experimental and control groups according to the level of formed of their ability to solve professionally oriented tasks are statistically significant. This means that students of the experimental group show an average higher level of knowledge, from which the conclusion about the advantage of experimental training follows.

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